CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

(1.) QA: L

Page: 1 Of: 14

2. DESIGN ANALYSIS TITLE			
Analysis of MPC Access Requirements for Addition of Filler Materials (SCPB: N/A)			
3. DOCUMENT IDENTIFIER (Including Rev. No.)			4. TOTAL PAGES
BB0000000-01717-0200-00010 REV 01			14
5. TOTAL ATTACHMENTS	6. ATTACHMENT NUMBERS - NO. OF PAGES IN EACH		
None	N/A		
	Printed Name	Signature	Date
7. Originator	Wayne E. Wallin	Wayne E. Wallin	9/3/96
8. Checker	Jerry A. Cogar	Jerry A. Cogar	9/3/96
9. Lead Design Engineer	Carl W. Chagnon	CW Chagnon	9/3/96
10.QA Manager	D J Gilstrap	D. J. Gilstrap	9/3/96
11. Department Manager	Hugh A. Benton	Jerry A. Cogar FOR H.A. BENTON	9/3/96

12. REMARKS

2. DESIGN ANALYSIS TITLE
Analysis of MPC Access Requirements for Addition of Filler Materials
3. DOCUMENT IDENTIFIER (Including Rev. No.)
BB0000000-01717-0200-00010 REV 01

4. Revision No.	5. Description of Revision
01	Revised Section 7.2, 5th paragraph (page 11), to use proper material density units; expanded text to better clarify definitions of terms. Changed form of the "void space" equation (now expressed in terms of "shot solid fraction" rather than "shot void fraction"), and corrected the numerical example.

Table of Contents

1. Purpose

This analysis is prepared by the Mined Geologic Disposal System (MGDS) Waste Package Development Department (WPDD) in response to a request received via a QAP-3-12 Design Input Data Request (Ref. 5.1) from WAST Design (formerly MRS/MPC Design). The request is to provide:

> *3) Specific MPC access requirements for the addition of filler materials at the MGDS (i.e., location and size of access required).*

The objective of this analysis is to provide a response to the foregoing request. The purpose of this analysis is to provide a documented record of the basis for the response. The response is stated in Section 8 herein. The response is based upon requirements from an MGDS perspective.

2. Quality Assurance

The Quality Assurance program applies to this analysis. The work reported in this document is part of the analyses for the License Application Design phase; it focuses on compatibility of certain Multi-Purpose Canister (MPC) design features that interface with the MGDS. This activity can affect the proper functioning of the MGDS waste package; the waste package has been identified as an MGDS Q-List item important to safety and waste isolation (pp. 5, 16, Ref. 5.2). The waste package is on the Q-List by direct inclusion by the Department of Energy; a QAP-2-3 evaluation has yet to be conducted. The work performed for this analysis is covered by a Waste Package Development QAP-2-0 work control Activity Evaluation entitled "MPC Design Compatibility with the MGDS" (Ref. 5.3). The QAP-2-0 evaluation determined that such activities are subject to Quality Assurance Requirements and Description (Ref. 5.4) requirements. Applicable procedural controls are listed in the activity evaluation.

3. Method

Information from the MPC Conceptual Design Report (CDR) (Ref. 5.5) was used as the source of MPC conceptual design configurations. It is from these configurations that various means and sequences have been conceptualized for opening the MPC for the purpose of addition of filler material, reclosure of the MPC if required, and finally closure of the MPC disposal container. It must be noted that remarks in Sections 4.3 and 7 such as "this assumption does not require any change to the MPC design" make reference to the MPC-CDR (Ref. 5.5) conceptual design configurations; thus, any future MPC design departures from these design configurations shall then have to be examined and reviewed to confirm design suitability regarding addition of filler material.

Note that a filled and sealed disposal container is a waste container; and that a waste container plus shielding, packing and other absorbent materials immediately surrounding a waste container is a waste package. However, as a consequence of historical usage, the term waste package is also used frequently as a generic reference to both disposal container and waste container.

No design method or analytical model has been employed in this document.

4. Design Inputs

4.1 Design Parameters

N/A (not applicable)

4.2 Criteria

As an integral part of the disposal waste package, the MPC shall provide for the addition of filler material as mandated by the MGDS Requirements Document (MGDS-RD) (Ref. 5.6), Section 3.2.3.2.3, MGDS-Transportation Interface Requirements:

4.2.1 1) Paragraph S. "The MGDS shall have the capability to cut open an MPC, remove and replace SNF without damage to the SNF, and re-seal the MPC for disposal.

The MPC design is responsible for providing the capability to be cut open and re-sealed for disposal at the MGDS."

2) Paragraph T. "The MGDS shall ensure that MPCs (as delivered to the MGDS) do not compromise the ability of the waste package to meet its requirements. This may require that MPCs be modified at the MGDS for the addition of filler material to contribute to criticality control, corrosion control, and heat transfer.

The MPC design is responsible for providing for the addition of filler material at the MGDS."

4.3 Assumptions

The <TBD> associated with assumption 4.3.7 will not be carried forward based on the rationale that the conclusions derived by this analysis are conservative bounding requirements that require no further confirmation.

4.3.1 For purposes of this analysis only, it is assumed that incorporation of the filler material option as part of the MGDS waste disposal design shall be a design requirement for disposal. The basis for this assumption is criteria 4.2.1(2), above. This assumption is used in the opening paragraph of Section 7, wherein the rationale is established that the assumption does not need to be carried through to the design outputs in Section 8, Conclusions.

4.3.2 To open the MPC at the MGDS for addition of filler material, it is assumed that the MPC would be opened by removal of the outer and inner lids and the shield plug. To meet criterion 4.2.1(1) herein, allowance is required for shell weld preparation to provide for the capability to reseal the MPC by replacement of the inner and/or outer lids. The technical requirement to reseal an opened MPC has not yet been established, as no performance credit is to be taken for the MPC shell. The basis of this assumption (regarding the manner of opening an MPC) is engineering judgement on the part of WPDD regarding the preferred design approach to cutting open a sealed MPC; this assumption does not require any change to the MPC design. This assumption is used in Section 7.2, and appears as a design output in Section 8, Conclusions.

4.3.3 It is assumed that the MPC spent nuclear fuel (SNF) basket and other internal structures must be designed 1) to provide access to essentially all free spaces within the MPC, including free spaces within any flux trap basket designs, with the MPC oriented vertically, and 2) to permit achievement of 85 percent minimum percentage free volume fill with filler material, with the MPC oriented vertically, based on loose as-poured filler bulk density. Free volume is defined as the MPC internal volume less displacement volume of all objects therein (e.g., fuel assemblies, basket components). The basis of these two assumptions is developed in Reference 5.7, in regard to design of SNF disposal criticality control measures. These assumptions are reiterated in both Section 7.2 and as design outputs in Section 8, Conclusions.

4.3.4 It is assumed that the reference filler material to be considered for purposes of achieving the aforementioned 85 percent fill will be graded iron/steel shot (or similar material), near-spherical, nominally in the range of 1 mm in diameter, specifically SAE Specification J444 Size No. 330. The basis of this assumption is engineering judgement based on physical characteristics of iron/steel shot, and physical features of typical SNF assemblies and SNF basket conceptual designs. This assumption is reiterated in both Section 7.1 and as a design output in Section 8, Conclusions.

4.3.5 It is assumed that re-establishment of a relatively inert atmosphere for the SNF (minimal amounts of oxygen and/or nitrogen) will be a requirement whether by resealing the MPC or upon sealing the disposal container. The basis for this assumption is a propagation of the original MPC requirement that the MPC be inerted as one step performed during the sealing process (predicated on avoidance of oxygen in particular, which would react with the fuel in the event of cladding perforation); this assumption does not require any change to the MPC design. This assumption is reiterated in Section 7.3; however, being a responsibility to be imposed on the MGDS, this assumption does not need to be carried through to the design outputs in Section 8, Conclusions.

4.3.6 It is assumed that achievement of the minimum fill would be by means of placement of a premeasured mass of filler material, the quantity appropriate to the particular type of MPC and SNF therein. Recovery from possible off-normal filling (e.g., not achieving the minimum fill) is an MGDS responsibility that will not impact the MPC design. The basis of this assumption is engineering judgement based on physical features of typical SNF assemblies and MPC basket conceptual designs. This assumption is reiterated in Section 7.4; however, being a responsibility to be imposed on the MGDS, this assumption does not need to be carried through to the design output in Section 8, Conclusions.

4.3.7 From the MGDS-RD (Ref. 5.6), Section 3.1.5, Major Considerations and Assumptions, Paragraph K:

> "It is assumed that the MPC will remain sealed through the expected life cycle and will not be opened at the MGDS unless addition of filler material at the MGDS may be required as part of preparation for disposal. An inert gas or other filler material <TBD> may be added to enhance heat transfer or to control criticality and corrosion. The filler, if required, may be added through a port that will then be sealed or the addition of filler may require the MPC to be opened."

4.4 Codes and Standards

4.4.1 Society of Automotive Engineers (SAE), SAE Specification J444, Cast Shot and Grit Size Specifications for Peening and Cleaning, May 1993

5. References

The following sources have been considered in this analysis:

5.1 QAP-3-12 Design Input Data Request, N. L. Seagle, 11/13/93, to W. D. Schutt, an attachment to Interoffice Correspondence CH.MRS.NLS.11/93.081, Stringer to Schutt, November 16, 1993, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O)

5.2 Q-List, YMP/90-55Q, REV 3, Yucca Mountain Site Characterization Project

5.3 Activity Evaluation, MPC Design Compatibility with the MGDS, Document Identifier Number (DI#) BB0000000-01717-2200-00003 REV 03, CRWMS M&O

5.4 Quality Assurance Requirements and Description, DOE/RW-0333P, REV 5, Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM)

5.5 Multi-Purpose Canister (MPC) Implementation Program Conceptual Design Phase Report, Volume II.A - MPC Conceptual Design Report, DI# A20000000-00811-5705-00002 REV 00, CRWMS M&O

5.6 Mined Geologic Disposal System Requirements Document, DOE/RW-0404, DI# B00000000-00811-1708-00002 REV 01 DCN 01, DOE OCRWM

5.7 Long-Term Criticality Control Issues for the MPC, DI# BB0000000-01717-0200-00008 REV 00, CRWMS M&O

5.8 Initial Review/Analysis of Thermal and Neutronic Characterisics of Potential MPC/WP Filler Materials, DI# BBA000000-01717-5705-00001 REV 00, enclosure to Correspondence LV.WP.WEW.5/94.113, May 13, 1994, CRWMS M&O

6. Use of Computer Software

N/A

7. Design Analysis

Based on design input assumption 4.3.1 herein, addition of filler material at the MGDS is an option which will be imposed as a requirement upon the MPC designs; that is, the assumption that filler material will be added to at least some of the MPCs does not in itself preclude use of the MPC without filler material. The requirement that the MPC be designed with access to add filler material is as a result indisputable; thus, assumption 4.3.1 and the associated requirement 1. in Section 8 do not require further confirmation. The following sections cover the development of the specific design requirements based on this assumption.

7.1 Filler Material Selection

MGDS waste package advanced conceptual design (ACD) studies (Ref. 5.8) have concluded that filler material, if used for purposes of moderator displacement to aid in criticality control, will be a granular material such as near-spherical graded iron/steel shot, nominally 1 mm in diameter. For purposes of this analysis, the material selected (assumption 4.3.4) will be considered as a reference material for demonstrating compliance with requirements 2. and 3. in Section 8, and as such, a bounding requirement that requires no further confirmation. The reference filler material to be considered for achieving the prescribed percent fill of an MPC shall be graded iron/steel shot (or similar material), near-spherical, nominally in the range of 1 mm in diameter, specifically SAE Specification J444 Size No. 330.

An important characteristic leading to selection of shot as the form of granular material for use as filler is that such material, being near-spherical and having a smooth hard surface, will "flow" readily; that is, when poured, the material will cascade and spread readily, such that the resulting angle of repose will be low (angle of repose is the bulk pile surface angle of inclination).

Desirable secondary features offered by iron/steel shot include cathodic protection by virtue of having highest electrochemical activity in comparison to other materials present within the MPC/waste package, and the shot will act as a mechanical packing to inhibit movement (collapse) of other materials internal to the MPC/waste package (fuel rods, fuel pellets, and/or basket materials).

Final selection of the MGDS filler material will be the subject of further studies, and of development test activities as may be deemed necessary. Subjects requiring further examination include, but are not limited to, placement of filler material (type, size, as-poured density and remaining interstitial space, "flow" characteristics, percentage of fill around a fuel assembly, off-normal recovery procedures), and determination of in-place behavior of filler material (thermal expansion effects, and effects of material oxidation [rusting] with consequential expansion and filling of available void spaces; that is, will either effect exert unacceptable mechanical forces on the fuel cladding or the waste container).

7.2 MPC Access to Add Filler Material

Much work remains before the decision is made whether to use filler material, including establishing objectives to be met, choice of material, minimum percentage filling necessary to achieve the objective(s), etc. For example, previous MGDS waste package ACD studies (Ref. 5.8) have concluded that filler material would have to achieve some minimum percentage fill to significantly aid criticality control (by means of moderator displacement). Reference 5.7 specifies the minimum allowable percentage free volume fill requirement as 85 percent for the MPC design.

Criterion 4.2.1(1) states in part: "....The MPC design is responsible for providing the capability to be cut open...." Criterion 4.2.1(2) states in part: "....The MPC design is responsible for providing for the addition of filler material at the MGDS." Although the requirement to provide "....the capability to be cut open...." is specifically related to removal/replacement of SNF, this requirement would similarly satisfy the MPC design requirement to provide "....for the addition of filler material...." Use of a "filler port" (assumption 4.3.7) would be an unacceptable design approach for addition of granular filler material such as shot, as such a port would not provide needed access to the entire cross-sectional area of the MPC.

To open an MPC at the MGDS, whether to add filler material or to remove and replace SNF, the current concept is to remove the MPC lids by cutting away each of the lid weld joints, followed by removal of the shield plug. MPC shell design must allow for weld preparation to provide the capability to reseal the MPC. As indicated in assumption 4.3.2, this approach to opening and providing the capability of resealing an MPC will require confirmation that any new MPC closure joint design configuration be functionally equivalent to that of the MPC conceptual design.

Filler material would be emplaced by cascading gravity "flow" of the material. Since "flow" can occur only in the manner of cascading flow (the filler material cannot upwell within any space into which the material may flow) access to essentially all free spaces is required. Furthermore, cascading flow could not be depended upon to carry the filler from the vicinity of the MPC centerline out as far as free spaces and openings adjacent to the inside perimeter (as would be the case if a "filler port" was to be incorporated into the design, as suggested by assumption 4.3.7). The filler material "flow stream" would be directed over the entire open top-end cross-sectional area of the MPC, whereupon the filler material is intended to flow down into all open free spaces internal to the MPC. The filler material is intended to flow around and throughout each and every SNF assembly resting within the MPC basket.

In general, free spaces within the MPC will not be permitted which would be inaccessible to gravity placement of filler material, with the MPC oriented vertically, especially if the purpose of the filler material is moderator displacement to aid in criticality control (Ref. 5.7). Design of the MPC basket and other internal structures must not preclude attaining 85 percent minimum percentage free volume fill, with the MPC oriented vertically, based on loose as-poured filler

bulk density. Free volume (space that could be occupied by moderator, before addition of any filler material) is defined as the MPC internal volume less displacement volume of all objects therein. Percentage fill refers to the volume of bulk shot needed to fill the stipulated percentage of free space; it does not refer to or include the interstitial void space within the bulk shot. (Note: bulk shot solid fraction = [1.0 - bulk shot interstitial void fraction] .) Total void space would equal { 1.0 − [fraction fill] × [bulk shot solid fraction] }; e.g., for the case of 85 percent fill, 4800 kg/m^3 shot, and 7860 kg/m^3 solid material density, void space equals { 1.0 − [0.85] × [4800/7860] } = 0.48.

As a consequence, the MPC basket and internals must be designed to provide access to essentially all free spaces within the MPC (including free spaces within any flux trap basket designs). Access to any free space shall be located as nearly as practical at the top of the space, with the MPC oriented vertically. The requirements for MPC free spaces accessibility and a minimum of 85 percent free volume fill are requirements emanating from, and the responsibility of, Reference 5.7, including rationale therefore.

It is assumed that achievement of the minimum fill would be by means of placement of a premeasured mass of filler material, the quantity appropriate to the particular type of MPC and SNF therein. The means of accomplishing and assuring minimum fill is an MGDS responsibility which will be accomplished at such time as use of filler in at least some MPC waste packages is determined to be a necessity. Recovery from possible off-normal filling (e.g., not achieving the minimum fill) is an MGDS responsibility that will not impact the MPC design.

7.3 Re-establishment of MPC Inert Atmosphere

In accordance with design input assumption 4.3.5 herein, those MPCs opened (such as to add filler) which are to be disposed of in the repository, will require re-establishment of a relatively inert atmosphere for the SNF, whether by resealing the MPC or upon sealing the disposal container. The objective would be removal of nearly all free oxygen and nitrogen within the MPC following addition of filler material; this to minimize potentially deleterious effects these free gases could have upon materials present within the MPC. The basis for this assumption is propagation of the original MPC requirement that the MPC be inerted as one step performed during the sealing process (predicated on avoidance of oxygen in particular, which would react with the fuel in the event of cladding perforation). This assumption does not require any change to the MPC design.

The assumed requirement to reinert the MPC is a requirement to be imposed on the MGDS. Reinerting would be accomplished either as a result of sealing and inerting of the MPC disposal container, provided that the MPC therein is left unsealed, or by resealing and reinerting an MPC after addition of filler. The first approach would be comparable to that to be used to inert an uncanistered fuel waste container.

7.4 Addition of Filler Material - Sequence of Operations

The following series of operations (the combination of both lists) may be performed on an MPC situated within the disposal container, or performed on a bare MPC which is later placed into the disposal container. No additional design features are required of the MPC beyond those design features required for initial closure of the MPC (e.g., means to handle the shield plug and closure lids).

Present MPC handling concepts for addition of filler material do not require lifting a loaded MPC after removal of the outer and inner lids. Such a handling feature is not a requirement; however, availability of a handling feature to allow lifting a loaded MPC, or even a loaded MPC with filler added, would provide the MGDS with more design options in the future.

The operations to be performed at the MGDS, to provide access for addition of filler material to an MPC, include:

- cutting and removal of each lid (including the honeycomb steel spacer),
- removal of the drain pipe from the inner lid,
- removal of the shield plug,
- disposal of the drain pipe within the MPC (place in approximately original position)
- addition of filler.

The foregoing operations comprise the actions necessary to accomplish the "MPC access requirements for addition of filler materials."

The operations to be performed at the MGDS (for which the MGDS would be responsible), following addition of filler material to an MPC, include:

For the case in which the MPC is not to be resealed:

- replacement of the shield plug,
- replacement of the inner lid, and
- replacement of the honeycomb and the outer lid.

(Replacement of any or all of these MPC components would primarily be for the purpose of confining the filler material in place, as the waste container is transitioned from the vertical position in the Waste Handling Building and transported to the horizontal in-drift final emplacement position. A secondary purpose of disposing of these components is to avoid creation of a waste stream of discarded components.)

For the case in which the MPC is to be resealed and reinerted:

- replacement of the shield plug,
- replacement of the inner lid,
- seal-welding of the inner lid,
- removal of the welded disc on the inner lid which covers the fill/vent connection,
- reinerting the MPC by evacuation and backfill with inert gas,
- welding another disc over the fill/vent connection,
- replacement of the honeycomb steel spacer,
- replacement of the outer lid, and
- welding of the outer lid.

8. Conclusions

The MGDS response to the WAST Design request #3, as was stated in Section 1, is as follows:

The requirement that the MPC be designed with access to add filler material is indisputable, even though addition of filler material at the MGDS is presently only an option; the design requirement does not in itself preclude use of the MPC without filler material. This design requirement for access to add filler material includes both 1) opening of the MPC, plus 2) access to essentially all free spaces therein. Therefore, the specific bounding requirements include:

1. The MPC shall be designed to provide the capability to be cut open and resealed at the MGDS by removal, replacement, and if required, resealing of the lids; the requirement emanates from the MGDS-RD, and requires no further confirmation. The current concept is to remove the MPC lids by cutting away each of the lid weld joints.

2. The MPC basket and internals shall be designed to provide access to essentially all free spaces within the MPC; that includes free spaces within any flux trap basket designs. Accessibility to any space shall be as nearly as practical at the top of the free space, with the MPC oriented vertically. The specific requirement of free spaces accessibility emanates from, and is the responsibility of, Reference 5.7; that requirement requires no further confirmation.

3. Design of the MPC spent nuclear fuel basket and other internal structures shall not preclude attainment of a certain minimum percentage free volume fill, with the MPC oriented vertically, based on loose as-poured filler bulk density. The specific requirement of 85 percent free volume fill emanates from, and is the responsibility of, Reference 5.7; that requirement requires no further confirmation.

4. The reference filler material for demonstrating compliance with requirements 2. and 3. above shall be graded iron/steel shot (or similar material), near-spherical, nominally in the range of 1 mm in diameter, specifically SAE Specification J444 Size No. 330. This filler material is a reference material solely for the stated purpose, and requires no further confirmation.

9. Attachments

N/A